NONPROVISIONAL PATENT APPLICATION

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BOX PATENT APPLICATION

NONPROVISIONAL APPLICATION TRANSMITTAL
RULE §1.53(b)

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Sir:

Transmitted herewith for filing under 37 C.F.R. §1.53(b) is the nonprovisional patent application

For (Title): DIGITAL SUBSCRIBER LINE COMMUNICATION SYSTEM

By (Inventors): Roman VITENBERG

☒ Formal drawings (Figs. 1-9; 9 sheets) are attached.
☐ A Declaration and Power of Attorney is filed herewith.
☐ An assignment of the invention to _____ is filed herewith.
☐ An Information Disclosure Statement is filed herewith.
☐ A statement to establish small entity status under 37 C.F.R. §§1.9 and 1.27 is filed herewith.
☐ A Preliminary Amendment is filed herewith.
☐ Please amend the specification by inserting before the first line the sentence --This nonprovisional application claims the benefit of U.S. Provisional Application No. _____, filed _____.--
☒ Priority of foreign applications No. 134401 filed February 6, 2000 in Israel and No. 136781 filed June 15, 2000 in Israel are claimed (35 U.S.C. §119).
☐ A certified copy of the above corresponding foreign application(s) is filed herewith.
☒ The filing fee is calculated below:

CLAIMS IN THE APPLICATION AFTER ENTRY OF ANY PRELIMINARY AMENDMENT NOTED ABOVE

FOR:	NO. FILED	NO. EXTRA	SMALL ENTITY RATE	SMALL ENTITY FEE		OTHER THAN A SMALL ENTITY RATE	OTHER THAN A SMALL ENTITY FEE
BASIC FEE				$ 345	OR		$ 690
TOTAL CLAIMS	35 - 20	= 15	x 9 =	$ 270	OR	x 18	$
INDEP CLAIMS	3 - 3	= 0	x 39 =	$	OR	x 78	$
☐ MULTIPLE DEPENDENT CLAIMS PRESENTED			+130 =	$	OR	+260	$
			TOTAL	$ 615	OR	TOTAL	$

* If the difference is less than zero, enter "0".

☒ Check No. 109618 in the amount of $615 to cover the filing fee is attached. Except as otherwise noted herein, the Director is hereby authorized to charge any other fees that may be required to complete this filing, or to credit any overpayment, to Deposit Account No. 15-0461. Two duplicate copies of this sheet are attached.
☐ This application is entitled to small entity status. DO NOT charge large entity fees to our Deposit Account.

Respectfully submitted,

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DIGITAL SUBSCRIBER LINE COMMUNICATION SYSTEM

FIELD OF THE INVENTION

The invention is generally in the field of communication and concerns a system for voice and data communication. More particularly, the present invention relates to a communication system on existing twisted pair telephone cables, utilizing digital subscriber line (DSL) technology.

BACKGROUND OF THE INVENTION

Existing plain old telephone service (POTS), based on a twisted pair telephone cable, is the most widespread communication infrastructure in the world. Technologies have been developed which permit to utilize existing telephone cables for the high rate data transmission characteristics of digital communication. These include digital multitone signal technology that permit to use the twisted pair telephone subscriber lines for multi media and high-speed data communication. Asymmetrical digital subscriber line (ADSL) allows the transmission of data or rate exceeding 8 Mb/s to a subscriber premise, and at a rate as high as 1 Mb/s in bi-directional communication. Such rates expand existing access capacity by 50 folds or more without the need for new cabling. ADSL can transform the existing public telephone network from one limited to voice, text and lower resolution graphics to a powerful, ubiquitous system capable to bringing multimedia, including full motion video, to every home.

An ADSL circuit includes an ADSL modem on each end of a twisted pair telephone line, creating three information channels – a high speed downstream channel, a medium speed duplex channel, and a POTS channel. The POTS channel is separated from digital modems by filters, thus guaranteeing uninterrupted POTS,

even if ADSL fails. The high speed downstream channels support a bit rate from about 1.5 to about 8 Mb/s, while duplex channels support rates which range between 16 to 1040 kb/s. Downstream data rate depend on a number of factors including the lengths of the copper line, the wire gauge, the presence of bridged taps, and cross cable interference. Line attenuation obviously increases with line length and frequency and decreases as wide diameter increases. A typical ADSL line will transmit at the rate of 1.5 Mb/s, with a wire diameter of 0.5mm, over a 5.5 km and at an 8 Mb/s over a distance of 3.7 km for a wire of the same diameter. For wire with a 0.4 mm diameter, the respective distances are 4.6 km and 2.7 km.

One problem of ADSL systems is the need to rewire existing telephone home networks within a subscriber premise and to place special splitter devices for separating voice and ADSL signal to a subscriber premise. In order to eliminate splitter and rewiring of home networks, a G.Lite ADSL system was developed, in which the separation between the ADSL and the voice signals is realized by means of special microfilters placed serially in the line connecting each home telephone device to the external line. However, the G.Lite system supports a bit rate up to 1.5 Mb/s only in a downstream direction, which is too slow for a variety of applications including, in particular, video-on-demand service. Furthermore the microfilter associated with a telephone device decreases the quality of voice communication.

In multi apartment buildings the telephone lines typically reach a central box and from there telephone lines extend to each of the apartments. In existing systems, such inter-building wiring is also not suitable for high-speed data communication. Typically, such inter-building wiring makes use of flat pair cables, which have unpredictable characteristics and are highly sensitive to RF noise.

Another problem of existing ADSL systems is that a customer must have an ADSL home modem and a personal computer at the subscriber premise. Every home device which requires high-speed data service from a telephone station, such as a video phone, digital TV, hi-fi digital audio, etc., must be connected to an ADSL home modem through a computer, typically a personal computer (PC). In practice this means that a location, to make use of an ADSL system, with intra-

location network capability, needs two independent networks: an existing telephone network and an additional digital data network.

A further problem of ADSL systems is that only one home modem may communicate with a modem at a central office of the communication service provider at the same time. If a subscriber has several computers, only one of them may thus be connected to the telephone line.

SUMMARY OF THE INVENTION

In accordance with the present invention a digital subscriber line communication system (DSLCS) is provided, which permits voice and data service to a subscriber premise using existing into and within (intra) building wiring without the need for installing any special communication equipment inside the subscriber premise. Any device in the home requiring high speed data communication from a communication service provider, e.g. a video phone, a digital TV, hi-fi digital audio device, a personal computer, etc., may be connected directly to existing telephone lines inside the subscriber's premise. Subscribing to an ADSL system does not require any laborious installation and in particular the subscriber does not require an ADSL modem and may get some special data services, e.g. for a digital TV or the like, without using a computer.

In accordance with the present invention use is made of a novel subscriber converter, that links between the twisted pair communication cable connecting to the central office of a communication service provider and the local wiring which leads to the subscriber's premise. The subscriber converter has a splitter-isolator device that POTS-related signals therethrough without attenuation, while converting HPN signals from a subscriber premise to xDSL signals transmitted to the CO and *vice versa*.

A number of subscriber converters may be placed in a local box serving a group of local subscribers. Typically, such groups of subscribers will be included in a single building which may be a residential building, an office building, etc.

However, the group of subscribers may also be several houses located in a neighborhood connected by local wirings to the local box.

It should be explained that the term *"local communication box"* or *"local box"* used herein means to denote a central point to which both the subscriber communication line to the central office and the local wirings from the subscriber premise connect. Physically, such a *"local box"* may assume a form other than a box *per se*. It may be housed in more than one casings or at times may not be housed in a casing at all but may rather be included within the framework of a certain facility, within an enclosure, at times together with other equipment. Furthermore, as may also be appreciated, some of the associated devices which are described below as being included within a communication box, e.g. the video server, may at times be physically included as a separate device connected to a box including the subscriber converter.

In accordance with a first aspect of the invention there is provided a communication system, comprising:

- a central office (CO) of a communication service provider with xDSL modems within the CO, each modem being associated with a subscriber;
- a plurality of subscriber premises (SPs), each equipped with one or more telephone devices connected to a telephone line of the SP and one or more devices which can send or receive data over communication lines, the devices being connected to said telephone line by an HPN interface unit;
- one or more local communication boxes for each group of SPs, each group consisting of one or more SP linked to the communication box by local wirings;
- a twisted pair subscriber telephone line linking each SP-associated xDSL modem with the local box of said SP; and
- at least one subscriber converter included within the local box, each of which is associated with one SP that is connected to said box, said converter having a first terminal connected to said subscriber line and a second terminal connected to the subscriber-associated local wiring; said converter comprising an xDSL analog front end (AFE) module connected to said first terminal, an HPN

AFE module connected to said second terminal, a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage there through of low-frequency, POTS-related signals while not permitting passage there through of xDSL and HPN signals.

In accordance with another aspect of the invention there is provided a local network comprising:

- a group of one or more subscriber premises, each equipped with one or more telephone devices connected to a telephone line of the SP and one or more terminal devices, which can send or receive data over communication lines, the devices being connected to said telephone line by an HPN interface unit;
- one or more local communication boxes linked to SPs of the group by local wirings and linked to a central office of communication service provider by twisted pair subscriber telephone lines, comprising one for each SP of the group;
- at least one subscriber converter included within the local box, each of which is associated with one SP that is connected to said box, said converter having a first terminal connected to the subscriber line and a second terminal connected to the subscriber-associated local wiring; said converter comprising an xDSL analog front end (AFE) module connected to said first terminal, an HPN AFE module connected to said second terminal, a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage there through of low-frequency, POTS-related signals while not permitting passage there through of xDSL and HPN signals.

In accordance with a still further aspect of the invention there is provided a subscriber converter device comprising:

- a first terminal for connection to a subscriber line, which comprises a twisted pair cable linking the subscriber converter to a central office of a communication service provide;

- a second terminal for connection to a subscriber-associated local wiring linking the SC to an SP.
- an xDSL analog front end (AFE) module connected to said first terminal;
- an HPN AFE module connected to said second terminal;
- a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE; and
- a splitter-isolator module connected to both the first and the second terminals permitting passage there through of low-frequency, POTS-related signals while not permitting passage there through of xDSL and HPN signals.

The subscriber-associated local wiring, particularly where the local network is included within a building, is typically constituted from a flat pair cable.

The terminal devices may include a wide variety of devices, which can send or receive data over communication lines. These include personal computers, video devices, television sets, videophones, IP phones, hi-fi audio devices, and others.

For ADSL communication the HPN interface unit is typically an HPNA-2 interface unit and the analog AFE modules as well as a converter modules within the subscriber converter will be adapted accordingly. For VDSL communication, the HPN unit is typically an HPNA-3 interface unit and the subscriber converter will be adapted accordingly.

For a variety of publications the subscriber converters may be associated with a server computer, coupled to said xDSL-to-HPN converter module. The computer server may have an integral or may be linked to a remote digital port for coupling to accessory devices or terminal devices within the subscriber premise, will also be described and exemplified below.

The digital xDSL-to-HPN converter may particularly comprise:

- a first digital signal processor (DSP) for conversion of xDSL signals to digital data packets and for conversion of digital data packets to xDSL signals,

coupled to the xDSL AFE, to a first program memory and to a read and write memory (RAM);

- a second DSP for conversion of digital data packets to HPN signals and for conversion of HPN signals to digital data packets, coupled to the HPN AFE, to a second program memory and to a RAM;
- a data exchange controller coupled to the RAM, to said first DSP and to said second DSP for exchanging data between the two DSPs and between the DSPs and the RAM; and
- a control processor coupled to said first DSP, to said second DSP and to said data exchange controller.

The system and network of the invention may also comprise one or more video servers, typically connected to the digital port of the server computer. The video server may download video films or video broadcasts transmitted from the CO through the subscriber converter and then transmission of downloaded video films or the broadcasts to the subscriber premise through the subscriber converter. The rate of data transmission to the video server, e.g. the time required to download a video film, may at times be accelerated by downloading the data simultaneously through a plurality of SCs to which the video server is associated, which are those not in current use by their respective subscribers. The video server may be programmed to alternatively choose for downloading those subscriber converters not in use and SCs use a subscriber converter once use is commenced by the subscriber.

The video server may also be linked to other data receiving systems including, for example, satellite broadcasts receiving system, a cable TV receiver equipment, terminal receiver device for optical fiber transmission, and others.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic representation of an embodiment of a DSLCS of the invention.

Fig. 2 is a block diagram representation of a subscriber converter in accordance with an embodiment of the invention, useful in the DSLCS of Fig. 1.

Fig. 3 is a block diagram representation of a subscriber converter in accordance with another embodiment of the invention.

Fig. 4 is a schematic representation of a DSLCS in accordance with an embodiment of the invention.

Fig. 5 is a schematic representation of another embodiment of a DSLCS of the invention.

Fig. 6 is a block-diagram representation of a video server device in accordance with an embodiment of the invention.

Fig. 7 is a schematic representation of a DSLCS in accordance with another embodiment of the invention.

Fig. 8 is a schematic representation of a DSLCS in accordance with another embodiment of the invention.

Fig. 9 is a schematic representation of a DSLCS in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is first being made to Fig. 1 showing a DSLCS **101** in accordance with an embodiment of the invention. The system shown in Fig. 1 comprises central office (CO) **103** of a telephone service provider, linked to a multi-apartment building **107** by twisted pair telephone cables **121**, included within cable **105**. CO **103** includes a plurality of xDSL office modems **106** included within the office's xDSL equipment **108** each one connected to one of twisted pair

cables **121**. Each xDSL modem **106** is further connected to the telephone network **135** and to data network **137** to provide POTS and data service, respectively, to the subscribers.

Building **107** includes a number of subscriber premises **109**, typically each being included in a separate apartment of the building, as well as a local central communication box **123** with twisted pair cables **121** leading into box **123**. Box **123** is also connected by a plurality of intra-building cables **111**, to each of the subscriber premises **109**, cables **111** being typically a flat pair cable (although at times it may also be a twisted pair). The subscriber premise, in accordance with this embodiment, comprises one or more telephone devices **115** (only one shown in the illustration of Fig. 1) and one or more computers, typically personal computers (PCs) **113** (two are illustrated in Fig. 1). Each of PCs **113** is connected directly to a connector **117** of the telephone line **119** through an associated or integral HPN (home phone network) interface device **114**. The telephone device **115** is also connected to telephone **119** through a similar connector.

Local box **123** comprises a plurality of xDSL/HPN subscriber converters **125**, one for each subscriber premise **109**. Each subscriber converter is connected to and links between a twisted pair **121** and an intra-building cable **111**.

The structure of an xDSL/HPN converter **125** is shown in Fig. 2. It comprises a splitter-isolator **203**, including a high-pass filter **203A**, a low-pass filter **203B** and an HPN line transformer **203C**, linking between an input connector **205** and an output connector **207**, an xDSL analog front end (AFE) module **209** coupled to input connector **205** via capacitors **210** of a high-pass filter **203A**, an HPN AFE module **211**, coupled to output connector **207** via solenoids **212** of transformer **203C** and a digital xDSL/HPN converter module **213** coupled to xDSL AFE module **209** and to HPN AFE module **211**. A computer server **215** is coupled to converter module **213** and to a digital interface port **217**. Input connector **205** and output connector **207** are connected, respectively, to twisted pair cable **121** and to intra-building cable **111**.

Communication system **101** provides voice and digital data service to every subscriber premise **109** of building **107**. Voice signals from telephone network **135** are routed through a POTS-splitter (not shown) of the CO xDSL equipment **108**, into twisted pair cable **121**. Data signals from data network **137** are converted to xDSL line signals by the office modem **106** and are then also routed into the same subscriber twisted pair **121**. The CO may use standards sDSL equipment like ADSL or VDSL modems and may function in a similar way to that in existing ADSL or VDSL systems.

Voice signals from telephone **115** inside the subscriber premise pass through cable **111** and then through splitter isolator **103** of subscriber converter **125**, without any attenuation. Data signals from PC **113** are converted to HPN line signals by the HPN interface device **114** and are then converted to ADSL line signals within the subscriber converter **125**. The HPN line signals are first converted into a digital form by the HPN AFE device **211** and then pass through the digital xDSL/HPN converter module **213**, which through a digital signal processing decodes the digital data which can subsequently be stored within an internal memory of device **213**. A unit within the xDSL/HPN converter module **213** reads the data, e.g. from the internal memory, and then, through a digital signal processing converts the data to discrete xDSL signals. The xDSL AFE module **209** then converts the discrete xDSL signals to analog xDSL line signals, which are then transmitted through input connector **205** and cables **121** to modems **106** of CO **103**.

Computer server **215**, which is optionally provided in some embodiments of the invention, can exchange data with the internal memory of the xDSL/HPN converter device **213** and may store data in its memory, which may subsequently be used by the subscriber. For example, the computer server **215** may be programmed by the customer to store and automatically update internet pages such as news pages, sport information, business information and others. A digital interface port **217** may be used for connection of server **215** to other devices to realize various additional potential features as will be described further below.

The conversion of line xDSL signals transmitted through cable **121** from the CO, to HPN also takes place within subscriber converter **125**, in a similar way, *mutatis mutandis*. Received xDSL signals are converted by the xDSL AFE module **209** into a discrete digital form and is then processed by the digital xDSL/HPN converter module which decodes the digital data. The digital data may be stored in the internal memory of device **213**. Another unit of the xDSL/HPN converter module **213** reads the data, e.g. from the internal memory, and then, through a digital signal processing converts the data to discrete HPN signals. The HPN AFE module **209** then converts the discrete HPN signals to analog HPN line signals.

The DSLCS of the invention has several important features. For one, in installing the DSLCS there is no need for rewiring of existing intra-building wires as in the case of full rate ADSL and there is further no need for microfilters like in the case of splitterless ADSL. Further, the DSLCS of the invention achieves high performance communication with the xDSL office equipment, as it uses the twisted pair telephone cables directly connected to a subscriber converter. This decreases noise and RF interference on the xDSL line, as compared to existing systems, and terminates bridge tapes problems common in a splitterless ADSL.

Another important feature of the invention is that every PC in the subscriber premise may be connected to the CO at the same time, through the subscriber converter. Furthermore, any device in the subscriber premise that needs high speed data services from a communication service provider, such as video phones, digital TV, hi-fi digital audio and others, may be connected directly to existing telephone connectors inside the premises, with no need to connect such devices, via a computer.

The computer server of the subscriber converter may support many different applications. For example, the computer server may, in accordance with some embodiments of the invention, replace the subscriber's PC. For this purpose, the subscriber premise may include a terminal device which may execute functions

such as video phone, personal computer function, internet connection, remote control to different home utilities, and others.

The invention may be realized both with different xDSL standards (e.g. ADSL, VDSL, SDSL, HDSL) and different HPN standards (e.g. HPNA-1, HPNA-2, NDSL).

Reference is now being made to Fig. 3 showing, by way of a blocked diagram, the structure of a subscriber converter **325** in accordance with another embodiment of the invention. This subscriber converter utilizes ADSL DMT standard for communication with the CO and HPNA-2 standard for intra-building communication. This converter may support a home network communication with a bit rate of up to 10 Mb/s, a downstream bit rate from the CO at up to 10 Mb/s (over a line having a distance of up to 3 Km) and an upstream bit rate to the CO of 1 Mb/s.

Subscriber converter **325** comprises a splitter isolator **403** linking between input connector **405** and output connector **407**, an ADSL AFE module **409**, coupled to input converter **405**, an HPNA-AFE module **411** coupled to output connector **407** and a digital ADSL/HPNA-2 converter module **413** coupled to the ADSL AFE module **409** and to the HPNA-2 AFE module **411**. An optional computer server **415** is coupled to converter device **413** and to a digital interface port **417**. The input connector **405** is connected to a twisted pair telephone cable **321** connected to the CO and the output connector **407** is connected to flat or twisted pair **311** of intra-building wiring.

The splitter isolated **403** comprises high-pass filter **421**, a low-pass filter **423** and an HPN line transformer **425**.

An input ADSL signal from the twisted pair **321** inputs the ADSL AFE device **409** through high-pass filter capacitors **424**. Voice signal passes through the low-pass filter **423**, having typically band widths of about 8 kHz, and given the fact that the frequency diapason of the voice signal is about 0.3-4 kHz, it passes therethrough without attenuation. Against this, ADSL line signals are allocated in a diapason of about 30 kHz-1.1MHz. the HPNA-2 signals are allocated in a diapason

of 4 MHz-10MHz. Thus, the low-pass filter **423** has a very high attenuation for ADSL HPNA-2 signals (about 60-80 dB) and thus provides an effective isolation of such signals between input connector **405** and output connector **407**. HPNA-2 signals are routed into intra-building wiring **311** through the line transformer **425**, which has a very low impedance for voice signals. An output capacitor **427** of low-pass filter **423** has a very low impedance for the HPNA-2 signals.

ADSL AFE module **409** comprises an ADSL line transformer **429**, a line driver integrated circuit (IC) **431** and a ADSL AFE IC **433**. Resistors **435** match the impedance of device **409** with impedance of twisted pair **321**. Line driver **431** and the ADSL AFE IC **431** may be selected from a variety of such devices known *per se*. ADSL AFE IC **433** comprises an analog receiver filter **451**, an analog transmitter filter **453**, analog-to-digital converter (ADC) **455**, digital-to-analog converter (DAC) **457** and a digital parallel interface (DPI) block **459**. The ADSL AFE IC **433** converts the received DMT signal to an output word, an converts an input digital word into an analog DMT signal. The digital word may for example be a 14 bit word. Output digital words are outputted from ADSL AFE device **409** through output bus **463** and input digital words are inputted through input bus **461**.

HPNA-2 AFE module **411** may be selected from a wide variety of available devices known *per se*. The HPNA-2 AFE module **411** comprises a line driver **465**, a receiving filter **467**, an ADC **469**, a DAC **471** and a DPI **473**. The HPNA-2 module **411** converts received QAM signals to output digital words and converts input digital words into a QAM signal. The digital words may, for example, be 12 bit digital words. The input digital word is inputted to the HPNA-2 module **411** by input bus **475** and the output digital word is outputted through output bus **477**. The digital ADSL/HPNA-2 converter module **413** includes a VSLI circuit. It comprises a first DSP **479**, a first program memory **481** loaded with a micro-program for the ADSL signal processing, a second DSP **483**, a second program memory **485** loaded with a micro- program for the HPNA-2 signal processing, a data exchange controller **487**, a buffer RAM **489** and a control processor **491**. The first DSP **479** is

controlled by the micro-program in first program memory **481** and is coupled to the ADSL AFE device **433** by input and output buses **461, 463**. The second DSP **481** is controlled by the micro-program in second program memory **485** and is coupled to the HPNA-2 AFE module **411** by input and output buses **475, 477**. Control purser **491** may be coupled to an optional server computer **415**, the latter being coupled to a digital interface port **417**.

In operation, QAM line signals from an HPNA-2 interface module associated with a computer in the subscriber premise, is transmitted through the intra-building wiring **311** to output connector **407**. Voice signals pass without attenuation through a splitter-isolator **403**, in a similar manner as that described in connection with the embodiment of Fig. 2. QAM line signals are converted into a digital form by the HPNA-2 AFE module **411** and then passed to second DSP **483** of the digital ADSL/HPNA-2 converter module **413**, which through signal processing decodes the digital QAM signal. The decoded data may be stored in buffer RAM **489**. First DSP **479** receives the information data, e.g. reads this data from RAM **489**, and through digital signal processing converts this data to discrete DMT signals which are outputted through bus **461** to ADSL/HPN-2 converter **413**. Received DMT signals are converted by the ADSL AFE device **409** to analog DMT line signals.

An optional server computer **415** may be provided, coupled to control processor **491** through a digital interface port. This computer server may provide for a variety of different applications, similarly s described above in connection with Fig. 2.

Reference is now being made to Fig. 4 showing a schematic representation of another embodiment of a DSLCS, generally designated **301** in accordance with an embodiment of the invention. A local box **323** comprising subscriber converters **325**, of the kind shown in Fig. 3, receives twisted pairs telephone cables **321** and is connected through intra-building wiring **311** to the different subscriber premises **308, 309** and **310**. As will be appreciated, although three subscriber premises are illustrated, this is an example only to illustrate some

different types of subscriber network configurations within a subscriber premise. Subscriber premises **309** is similar to subscriber premise **109** shown in Fig. 1 with the same components designated by the same reference numerals, shifted by 200. The subscriber premises **309** comprises a video phone **354**, an IP telephone **355**, a regular telephone device **315** and a printer **357**. Video phone **354** and IP telephone **355** are connected to telephone line **319** by HPNA-2 interface blocks **314**, while telephone **315** is directly connected to line **319**. The IP telephone **355**, the videophone **354** and the telephone **315** may work simultaneously to provide three voice channels with the CO. There is essentially no limit to the number of IP telephones that may be connected to subscriber line (typically more than 20 units). The videophone **354**, may in some embodiments of the invention, work in conjunction with the optional computer server **415**, in which case the video phone may support internet service. Also included in subscriber premise **308** is a printer **357** which is linked to line **319** also through an HPNA-2 interface **314** and may again operate in conjunction with the computer server **415**.

Subscriber premise **310** comprises an HD-TV **335**, a terminal device **337**, a DVD device **341**, a digital audio recorder **339**, all connected to the telephone line by means of an HPNA-2 interface block **314**. Also included in premise **310** is a common telephone **315**, directly connected to line **319**. Subscriber premise **310** further comprises a wireless set-top box **343** that may control different home devices and mechanisms by means of RF frequency.

The HD-TV **335** may receive video programs transmitted from the CO, and may also display a video films transmitted from DVD device **341**. The terminal device **337** is coupled to and works in conjunction with the computer server of the subscriber converter to replace a home PC and may be used for control of all devices connected to telephone line **319**. As may be appreciated, the subscriber converter is continuously in operation and may be programmed by terminal device **337** to monitor other home devices and appliances through the wireless set-top box **343**.

In a premise configuration of the type of premise **310**, many services and applications may be obtained without the need for a home PC at the subscriber premise such as, for example, printing newsletters, electronic mail service, fax service, Internet service, and others.

A DSLCS **601** in accordance with another embodiment of the invention is shown schematically in Fig. 5. In this figure, like components to those of Fig. 1 were given like reference numerals shifted by 100, and the reader is referred to the description of Fig. 1 for explanation of their nature and function. Building **307** of this embodiment comprises, within box **323**, a video server **375** linked through interface cable **379** to interface ports **380** of subscriber converter **325**. HD-TV set **335** comprises a MPEG decoder **351** and an HPNA-2 interface device **314**, linked, through socket **317**, to telephone line **319**. Data network **337** is linked to a video-service provider **302**. Video server **375** permits a customer a video-on-demand service, a video-library service as well as other database service.

One embodiment of a video server **375** is illustrated by block diagram, in Fig 6. Video server **375** comprises a large size memory **501**, coupled to a memory controller **503**; a host processor **505**; a plurality of subscriber channels, one for each subscriber converter, each comprising a buffer RAM **509** linked to memory **501** by means of bus **511**, each buffer RAM being coupled to an interface controller **507** which is in turn connected to interface cable **379**; high speed interface ports **513** and **517**, both connected to a demultiplexer **515** and coupled to the host processor **505**; and a plurality of RAMs **519**, one for each subscriber converter, coupled to memory **501** by means of bus **521**.

The host processor controls the different devices or modules of a video server **375** and is controlled by a program which may be loaded from a floppy disk, from a CD ROM, etc., or from the CO, channel **201** of the subscriber converters. The host processor may be directly coupled to devices within the subscriber converter for control of their operation, and may also communicate with the office xDSL modem, at the CO. The host processor supports video-on-demand service and video library service for each of the customers linked to local box **323**. The

high speed port **513** and **517** as well the as demultiplexer **515** are useful for a connection to external devices, as will be described below with reference to two applications, video on demand service and video library service.

The DSLCS of Fig. 5 provides video-on-demand service, e.g. as described in the following. A customer may access computer server **415** either from a PC **313** or from a terminal device **337** and may order a video film, e.g. by sending to the host computer an Internet URL code. Video server **375** then establishes communication with video-provider **302**. The video film may be transmitted by data packets with a bit rate, for example, 1.5 Mb/s by using ADSL downstream communication protocol or at a higher rate by the use of VDSL protocols, as available. Each data packet includes an ID number that comprises information about the transmitted film and the serial number of the packet. The received data packet transmits through interface port **380** to video server **375**. The interface controller **507** then rights the data packet into buffer RAM **509**. The host processor reads the ID number of the data packet stored in each buffer RAM **503** and then rights the packet into memory **501** together with the ID numbers to eventually produce a video film file. After the end of the transmission, the host processor may insert the name of the file into a catalog and send a message to the customer. The film may then be accessed by the relevant subscribers. The film may be retrieved from the memory and then transmitted to HD-TV **335** through HPN interface **314** and decoder **351**.

The loading of the film may conveniently be done during off-peak hours. As will be appreciated, memory **501** may be used for storage of data files other than video films. For example, each subscriber may assign a part of the memory for storing a backup for his PC as well as for any other data or programs.

Video library service may be realized in a similar manner. The video provider **302** may periodically send to a subscriber newly released films.

Fig. 7 illustrates a DSLCS **801** in accordance with another embodiment of the invention. Most components of the system are the same to those of Fig. 5 and the reader is referred to the relevant description below for understanding of their

nature and function. A DSLCS **801** in accordance with this embodiment comprises a satellite antenna **369**, typically placed on the building's roof, and connected by a coaxial cable **365** to a TV satellite receiver **367**, placed inside the local box **323**. Satellite receiver **367** is associated with an MPEG coder **361** and a multiplexer **366**, connected to video server **375** by means of length to video server **375** by means of a coaxial cable **378**. An interface cable **381** connects receiver **367** to an interface port of video server **375**. In this embodiment, the customer has the choice of ordering a broadcast, a video, etc., through satellite communication in addition to his ability to obtain such service through the CO **303**. Furthermore, satellite communication may also be used in this embodiment for a variety of other services including, for example, Internet services.

Fig. 8 illustrates a DSLCS **901** in accordance with another embodiment of the invention, which additionally supports also cable TV In this figure, like components to those of Fig. 7 have been given like reference numerals and the reader is referred to the description above for explanation of their nature and function.

A cable TV receiver **383** is included within local box **323** and is connected to different cable TV providers **304**, typically by coaxial cables **385**. Each cable TV receiver **383** is connected to a multi-channel MPEG coder **387** which is in turn linked to multiplexer **366**, connected to video server **375**. The system **901** provides data in both services from the CO, TV satellite broadcast services and cable TV service, all of which can be accessed by the customer through his HD-TV television set **335** with its associated decoder **351** and HPN interface block **314**.

Another embodiment of a DSLCS of the invention is shown in Fig. 9. System **1001** of this embodiment includes various components included in embodiments described above and the reader is referred to the above description for explanation of their nature and function. In the system of embodiment **1001**, included in local box **323** is a fiber optical receiver **91** connected to an optical cable **393** to a high speed data service provider **395** and through high speed data link **378** to high speed interface port of video server **375**. In order to realize high

speed data service, HPN blocks **314** will be of the high speed (100 Mb/s or higher) HPNA-3 interface devices. A fiber cable, as known, may support a bit rate up to about 155 Mb/s.

As will be appreciated, the specific embodiments described herein are merely an example and a large number of changes, or variations are possible, all being clear to the man of the art, all encompassed within the invention as defined herein. The above description is thus an illustration of the full scope of the invention and does not intend to be limiting.

CLAIMS:

1. A communication system, comprising:

- a central office (CO) of a communication service provider with xDSL modems within the CO, each modem being associated with a subscriber;
- a plurality of subscriber premises (SPs), each equipped with one or more telephone devices connected to a telephone line of the SP and one or more devices, which can send or receive data over communication lines, the devices being connected to said telephone line by an HPN interface unit;
- one or more local communication boxes for each group of SPs, each group consisting of one or more SP linked to the communication box by local wirings;
- a twisted pair subscriber telephone line linking each SP-associated xDSL modem with the local box of said SP; and
- at least one subscriber converter included within the local box, each of which is associated with one SP that is connected to said box, the subscriber converter having a first terminal connected to said subscriber line and a second terminal connected to the subscriber-associated local wiring; said subscriber converter comprising an xDSL analog front end (AFE) module connected to said first terminal, an HPN AFE module connected to said second terminal, a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, plain old telephone service (POTS) related signals while not permitting passage therethrough of xDSL and HPN signals.

2. A system according to Claim 1, wherein said group of SP's and said local box are all included within one building.

3. A system according to Claim 1, wherein said subscriber-associated local wiring comprises a flat pair cable.

4. A system according to Claim 1, wherein the terminal devices are selected from the group consisting of personal computer (PC), video device, television set, videophone, IP-phone, HI-FI audio devices.

5. A system according to Claim 1, wherein said HPN unit is an HPNA-2 interface unit and said subscriber converter comprises an ADSL AFE module connected said first terminal, an HPNA-2 AFE module connected to said second terminal, a digital ADSL-to-HPNA-2 converter module connected to the ADSL AFE and to the HPNA-2 AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, plain old telephone service (POTS) related signals while not permitting passage therethrough of ADSL and HPNA-2 signals.

6. A system according to Claim 1, wherein:

- said xDSL modems in the CO are VDSL modems;
- the HPN unit is an HPNA-3 interface unit; and
- said SP comprises a VDSL AFE module connected to said first terminal, an HPNA-3 AFE module connected to said second terminal, a digital VDSL-to-HPNA-3 converter module connected to the VDSL AFE and to the HPNA-3 AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of VDSL and HPNA-3 signals.

7. A system according to Claim 1, wherein one or more of said subscriber converters are associated with a server computer, which is coupled to said xDSL-to-HPN converter module.

8. A system according to Claim 7, wherein said server computer has or is linked to one or more digital ports for coupling to accessory devices or terminal devices within the SP.

9. A system according to Claim 1, wherein the digital xDSL-to-HPN converter comprises:

- a first digital signal processor (DSP) for conversion of xDSL signals to digital data packets and for conversion of digital data packets to xDSL signals, coupled to the xDSL AFE, to a first program memory and to a read and write memory (RAM);
- a second DSP for conversion of digital data packets to HPN signals and for conversion of HPN signals to digital data packets, coupled to the HPN AFE, to a second program memory and to a RAM;
- a data exchange controller coupled to the RAM, to said first DSP and to said second DSP for exchanging data between the two DSPs and between the DSPs and the RAM; and
- a control processor coupled to said first DSP, to said second DSP and to said data exchange controller.

10. A system according to Claim 9, wherein said control processor is coupled to a digital port for connection to one or more external devices.

11. A system according to Claim 10, wherein the external device is a computer.

12. A system according to Claim 8, comprising a video server connected to said digital port, for downloading video films or broadcast transmitted from the CO through said subscriber line and said subscriber converter and for transmission of downloaded Video films or broadcast to the subscriber converter through said subscriber converter.

13. A system according to Claim 12, wherein said video server can download video films or broadcast simultaneously through a plurality of subscriber converters, being those not in current use by the respective subscribers.

14. A system according to Claim 12, wherein said video server comprises a large memory for storage of video files and one or more data exchange modules for data exchange with the subscriber converters.

15. A system according to Claim 12, wherein said video server is linked to a data receiving system selected from the group consisting of satellite broadcast

receiving system, cable TV receiver equipment and terminal receiver device for an optical fiber.

16. A local network comprising:

- a group of one or more subscriber premises (SPs), each equipped with one or more telephone devices connected to a telephone line of the SP and one or more terminal devices, which can send or receive data over communication lines, the devices being connected to said telephone line by an HPN interface unit;
- one or more local communication boxes linked to SPs of the group by local wirings and linked to a central office of communication service provider by twisted pair subscriber telephone lines, comprising one for each SP of the group;
- at least one subscriber converter included within the local box, each of which is associated with one SP that is connected to said box, the subscriber converter having a first terminal connected to the subscriber line and a second terminal connected to the subscriber-associated local wiring; the subscriber converter comprising an xDSL analog front end (AFE) module connected to said first terminal, an HPN AFE module connected to said second terminal, a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of xDSL and HPN signals.

17. A network according to Claim 16, wherein said group of SPs is all included within one building.

18. A system according to Claim 16, wherein said subscriber-associated local wiring comprises a flat pair cable.

19. A network according to Claim 16, wherein said HPN unit is an HPNA-2 interface unit and said SP comprises an ADSL AFE module connected said first terminal, an HPNA-2 AFE module connected to said second terminal, a digital ADSL-to-HPNA-2 converter module connected to the ADSL AFE and to the HPNA-2 AFE and comprising a splitter-isolator module connected to both the

first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of ADSL and HPNA-2 signals.

20. A network according to Claim 16, wherein:

- the HPN unit is an HPNA-3 interface unit; and
- said SP comprises a VDSL AFE module connected to said first terminal, an HPNA-3 AFE module connected to said second terminal, a digital VDSL-to-HPNA-3 converter module connected to the VDSL AFE and to the HPNA-3 AFE and comprising a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of VDSL and HPNA-3 signals.

21. A network according to Claim 16, wherein one or more of said subscriber converters are associated with a server computer, which is coupled to said xDSL-to-HPN converter module.

22. A network according to Claim 21, wherein said server computer has or is linked to one or more digital ports for coupling to accessory devices or terminal devices within the SP.

23. A network according to Claim 16, wherein the digital xDSL-to-HPN converter comprises:

- a first digital signal processor (DSP) for conversion of xDSL signals to digital data packets and for conversion of digital data packets to xDSL signals, coupled to the xDSL AFE, to a first program memory and to a read and write memory (RAM);
- a second DSP for conversion of digital data packets to HPN signals and for conversion of HPN signals to digital data packets, coupled to the HPN AFE, to a second program memory and to a RAM;
- a data exchange controller coupled to the RAM, to said first DSP and to said second DSP for exchanging data between the two DSPs and between the DSPs and the RAM; and

- a control processor coupled to said first DSP, to said second DSP and to said data exchange controller.

24. A network according to Claim 23, wherein said control processor is coupled to a digital port for connection to one or more external devices.

25. A network according to Claim 24, wherein the external device is a computer.

26. A network according to Claim 22, comprising a video server connected to said digital port, for downloading video films or broadcast transmitted from the CO through said subscriber line and said subscriber converter and for transmission of downloaded Video films or broadcast to the SP through said subscriber converter.

27. A network according to Claim 26, wherein said video server can download video films or broadcast simultaneously through a plurality of subscriber converters, being those not in current use by the respective subscribers.

28. A network according to Claim 26, wherein said video server comprises a large memory for storage of video files and one or more data exchange modules for data exchange with the subscriber converters.

29. A network according to Claim 26, wherein said video server is linked to a data receiving system selected from the group consisting of satellite broadcast receiving system, cable TV receiver equipment and terminal receiver device for an optical fiber.

30. A subscriber converter device comprising:

- a first terminal for connection to a subscriber line, which comprises a twisted pair cable linking the subscriber converter to a central office of a communication service provide;
- a second terminal for connection to a subscriber-associated local wiring linking the subscriber converter to a subscriber premise (SP).
- an xDSL analog front end (AFE) module connected to said first terminal;
- an HPN AFE module connected to said second terminal;

- a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE; and

- a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of xDSL and HPN signals.

31. A subscriber converter according to Claim 30, wherein:

- an ADSL AFE module is connected said first terminal;

- an HPNA-2 AFE module is connected to said second terminal;

- a digital ADSL-to-HPNA-2 converter module is connected to the ADSL AFE and to the HPNA-2 AFE; and

- a splitter-isolator module is connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of ADSL and HPNA-2 signals.

32. A system according to Claim 30, wherein:

(a) an VDSL AFE module is connected said first terminal;

(b) an HPNA-3 AFE module is connected to said second terminal;

(c) a digital VDSL-to-HPNA-3 converter module is connected to the VDSL AFE and to the HPNA-3 AFE; and

- a splitter-isolator module is connected to both the first and the second terminals permitting passage therethrough of low-frequency, POTS-related signals while not permitting passage therethrough of VDSL and HPNA-3 signals.

33. A subscriber converter according to Claim 30, being associated or being connectable to a server computer.

34. A subscriber converter according to Claim 30, wherein the digital xDSL-to-HPN converter comprises:

- a first digital signal processor (DSP) for conversion of xDSL signals to digital data packets and for conversion of digital data packets to xDSL signals, coupled to the xDSL AFE, to a first program memory and to a read and write memory (RAM);

- a second DSP for conversion of digital data packets to HPN signals and for conversion of HPN signals to digital data packets, coupled to the HPN AFE, to a second program memory and to a RAM;
- a data exchange controller coupled to the RAM, to said first DSP and to said second DSP for exchanging data between the two DSPs and between the DSPs and the RAM; and
- a control processor coupled to said first DSP, to said second DSP and to said data exchange controller.

35. A system according to Claim 9, wherein said control processor is coupled to a digital port for connection to one or more external devices.

ABSTRACT

A communication system comprises a central office (CO) of a communication service provider with xDSL modems within the CO, each modem being associated with a subscriber and comprises a plurality of subscriber premises (SPs), each equipped with one or more telephone devices connected to a telephone line of the SP and one or more devices connected to the telephone line by an HPN interface unit, which can send or receive data over communication lines. Each group of SPs is linked to a local communication box by twisted pairs of subscriber telephone lines. The local box comprises at least one subscriber converter associated with one SP linked to the box, the subscriber converter having a first terminal connected to said subscriber line and a second terminal connected to the subscriber-associated local wiring. The subscriber converter comprises an xDSL analog front end (AFE) module connected to said first terminal, an HPN AFE module connected to said second terminal, a digital xDSL-to-HPN converter module connected to the xDSL AFE and to the HPN AFE and comprises a splitter-isolator module connected to both the first and the second terminals permitting passage therethrough of low-frequency, plain old telephone service (POTS) related signals while not permitting passage therethrough of xDSL and HPN signals. Provided is also a subscriber converter for use in the above system.

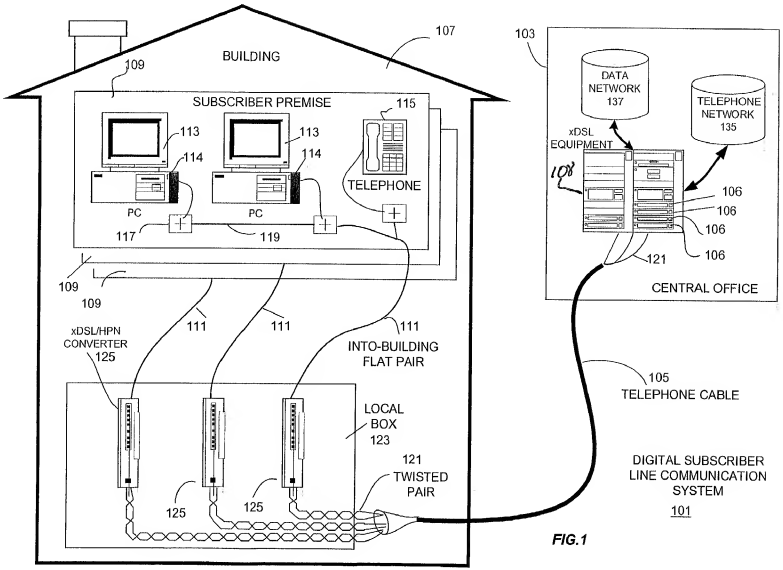
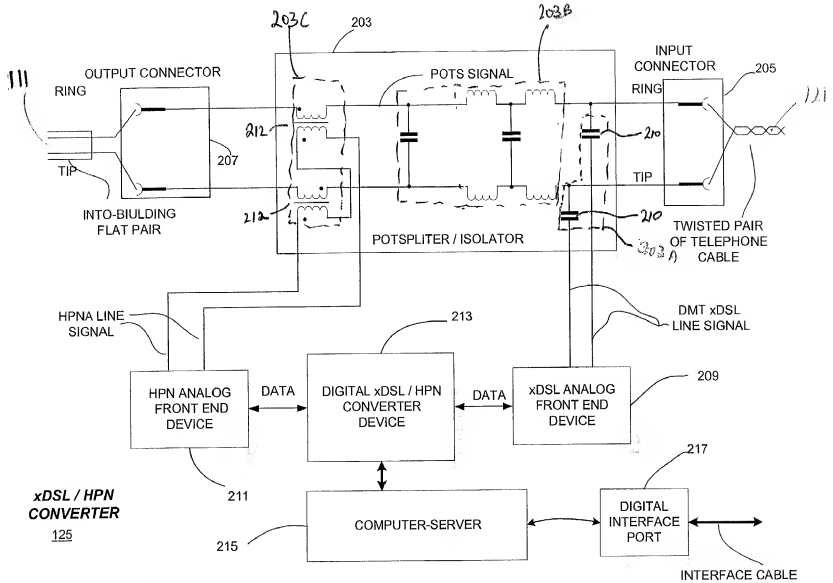


FIG.1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INPUT
CONNECTOR
205
RING
TIP
210
210
TWISTED PAIR
OF TELEPHONE
CABLE
HPNA LINE
SIGNAL
213
DMT xDSL
LINE SIGNAL
HPN ANALOG
FRONT END
DEVICE
DATA
DIGITAL xDSL / HPN
CONVERTER
DEVICE
DATA
xDSL ANALOG
FRONT END
DEVICE
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INTERFACE CABLE

FIG. 2

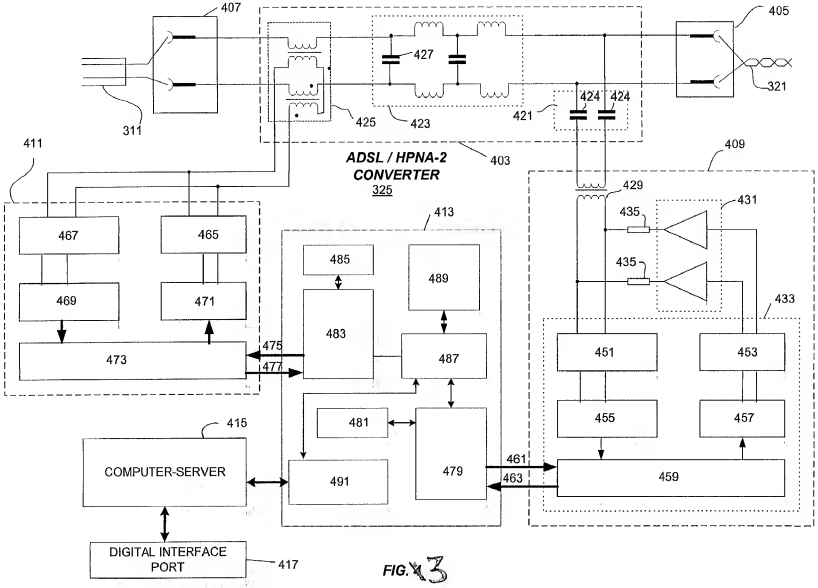
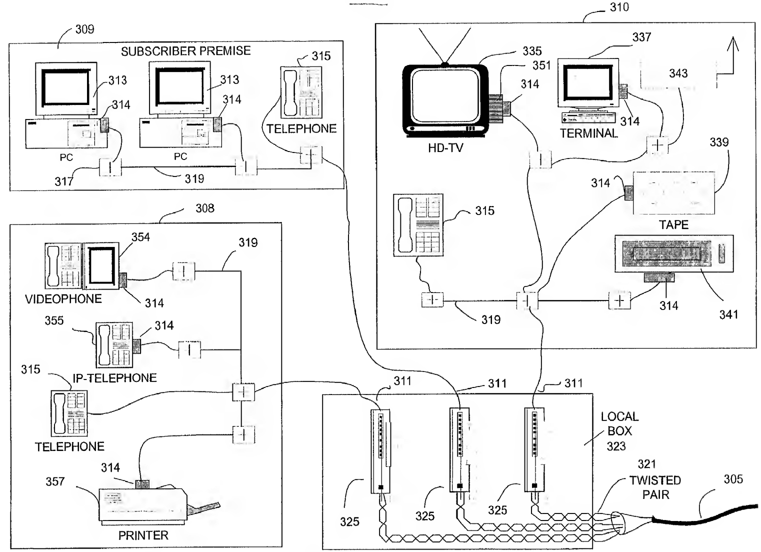


FIG. 13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HD-TV
TERMINAL
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TAPE
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308
354
319
VIDEOPHONE
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314
315
IP-TELEPHONE
TELEPHONE
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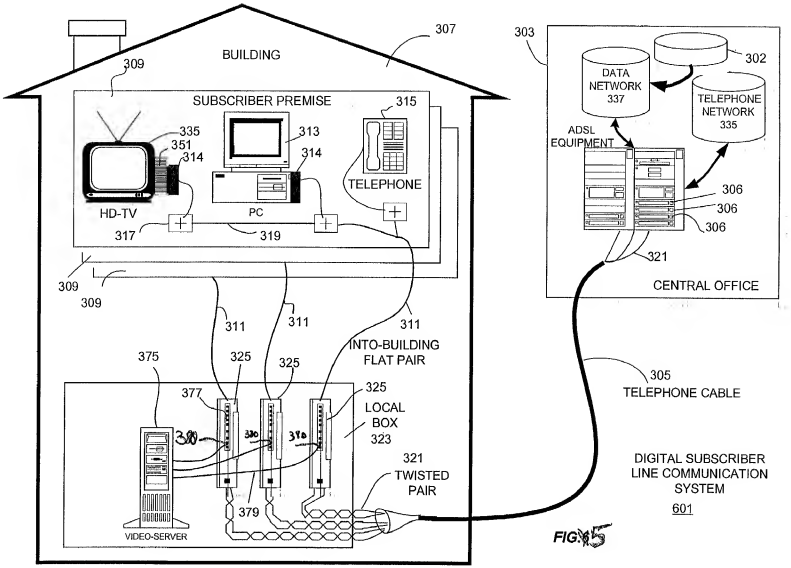
FIG. 4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TELEPHONE
HD-TV
PC
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311
INTO-BUILDING
FLAT PAIR
375
325
325
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LOCAL
BOX
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TWISTED
PAIR
379
VIDEO-SERVER
303
302
DATA
NETWORK
337
TELEPHONE
NETWORK
335
ADSL
EQUIPMENT
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306
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CENTRAL OFFICE
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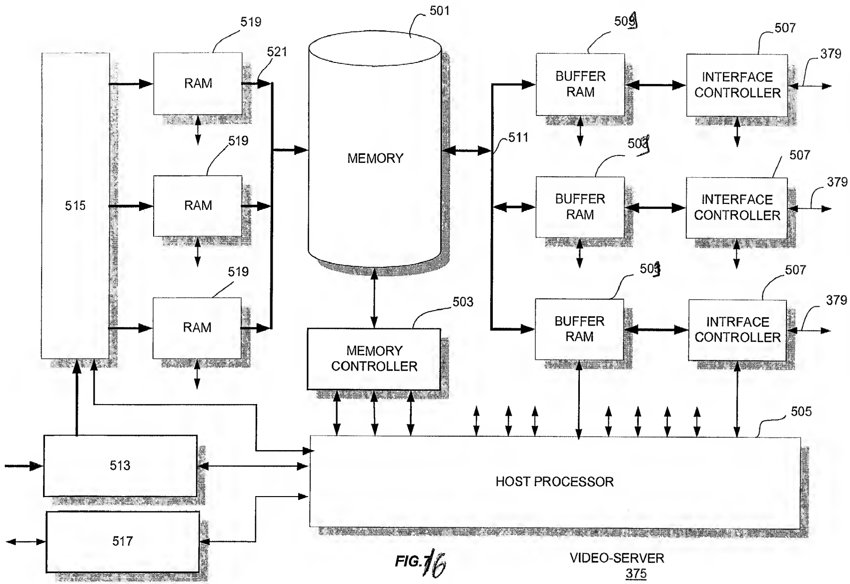
TELEPHONE CABLE
DIGITAL SUBSCRIBER
LINE COMMUNICATION
SYSTEM
601

FIG. 5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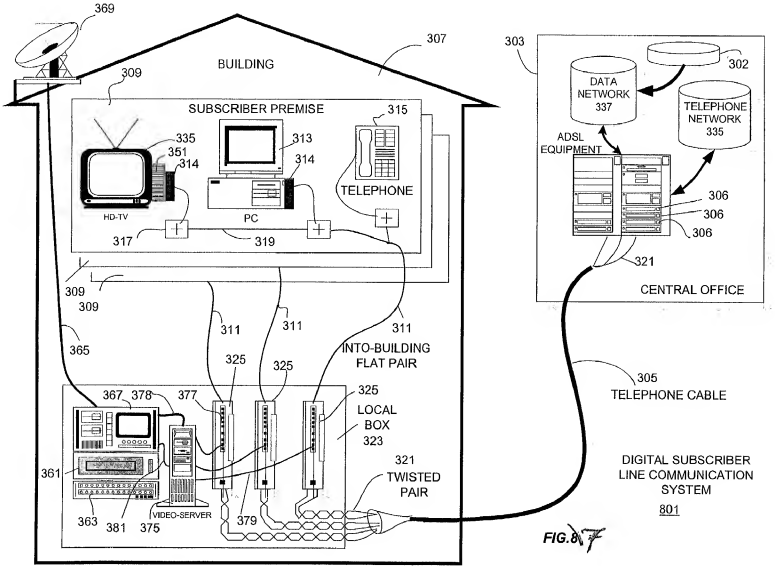
519
521
509
507
379
RAM
MEMORY
BUFFER RAM
INTERFACE CONTROLLER
511
515
503
INTRFACE CONTROLLER
MEMORY CONTROLLER
505
513
HOST PROCESSOR
517
VIDEO-SERVER
375

FIG. 16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319
DATA NETWORK 337
302
TELEPHONE NETWORK 335
ADSL EQUIPMENT
306
306
306
321
CENTRAL OFFICE
309
309
311
311
311
365
INTO-BUILDING FLAT PAIR
325
325
325
305
TELEPHONE CABLE
367
378
377
LOCAL BOX 323
361
321 TWISTED PAIR
DIGITAL SUBSCRIBER LINE COMMUNICATION SYSTEM
801
363
381
375
VIDEO-SERVER
379

FIG. 8

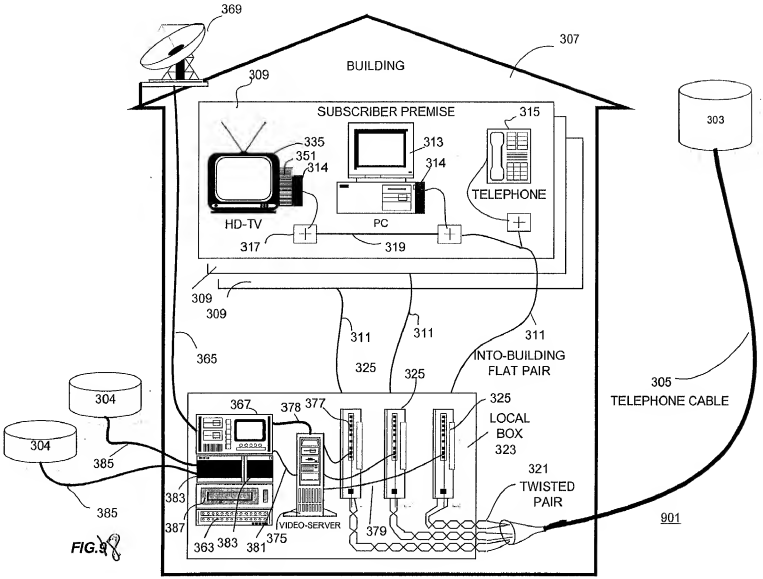
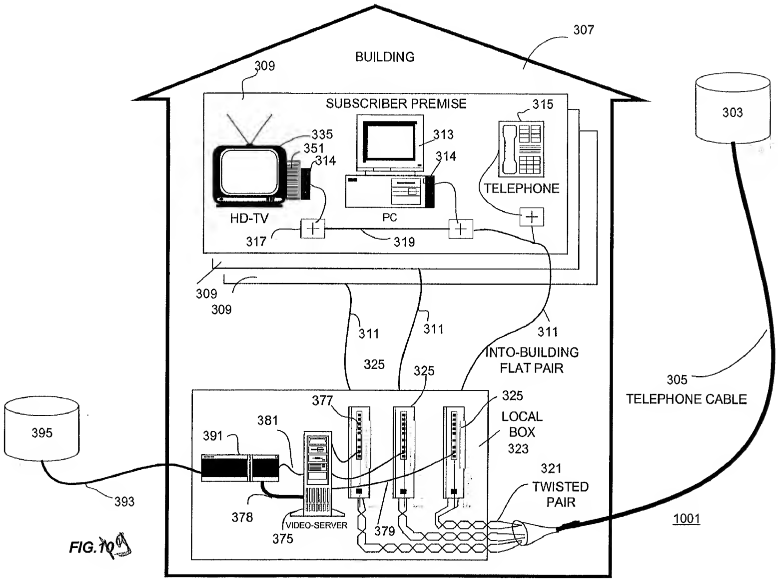


FIG. 9



BUILDING
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SUBSCRIBER PREMISE
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TELEPHONE
HD-TV
PC
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311
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311
INTO-BUILDING
FLAT PAIR
325
325
325
377
381
391
LOCAL
BOX
323
321
TWISTED
PAIR
378
VIDEO-SERVER
375
379
393
395
303
305
TELEPHONE CABLE
1001

FIG. 10